

OH2
371.3358
E244

Educational Television Series 1968-69

Teachers' Guide



Science Biology SENIOR DIVISION



Educational Television Branch
ONTARIO DEPARTMENT OF EDUCATION
1670 Bayview Avenue, Toronto 17

BIOLOGY

Senior Division

19 programs, 30 minutes each

General Introduction

Program one

What is Biology?

3

Program two

Looking at Cells

3

Program three

The Membrane of the Cell

4

Program four

Respiration 1 – The overall picture

4

Program five

Respiration 2 – The Mitochondrion and the Respiratory Chain

4

Program six

Respiration 3 – ATP, The Cell's Energy Currency

5

Program seven

DNA, The self-duplicating Molecule

5

Program eight

The Digestive System

6

Program nine

Muscles and Movement

6

Program ten

Nerves and Nerve Impulses

6

Program eleven

Insulin – A Co-ordinating Chemical

7

Program twelve

How Plants Lift Water

7

Program thirteen

Biology of the Flower

8

Program fourteen

Sexual Reproduction

8

Program fifteen

The Transmission of Genes

8

Program sixteen

The Expression of Genes

9

Program seventeen

The Evidence for Evolution

9

Program eighteen

Mechanism of Evolution

9

Program nineteen

Man in Biology

10

Please address your comments and questions to:

Assistant Superintendent,
Mathematics and Science,
Education Section,
ETV Branch,
1670 Bayview Avenue,
Toronto 17.

INTRODUCTION

This series of nineteen programs is intended for viewing by grade 13 students and their teachers. The programs have been planned to supplement some of the major topics contained in Curriculum S. 17 B.

It is quite impossible, in the time available, to deal with every topic in a curriculum that is virtually a survey of many of the most important fields of biology. The programs that are being presented therefore represent only a selection from among the dozens of topics that could have been used. Some have been chosen because they illustrate biological principles of fundamental importance, some because of their suitability for film and television presentation, others to aid teachers in their presentation of topics that are new to the secondary school biology program. The inclusion of a particular topic in the series is not meant to indicate that it is any more important than another topic which has been omitted. It would be possible to construct several such program series of equal significance without duplicating any of the topics presently included.

The programs are intended to complement the classroom instruction. In most cases, the pace of delivery is such that the maximum benefit will be obtained by students already having some familiarity with the topic. The teacher who wishes to incorporate this series into his teaching should therefore schedule classroom instruction and reading assignments accordingly. Since not all teachers will wish to follow the order of presentation adopted in the telecast schedule, each program is complete in itself and can be viewed with advantage at any time during the year.

One of the objectives of this series is to bring to the student experiences which are difficult to duplicate in the classroom. One such experience is that of contact with prominent scientists working in their respective fields, and a number of programs include interviews with such people.

Another such experience is that of seeing

some of the methods and equipment in common usage in the various fields of biology.

The general purpose of the series is to stimulate an interest in biology, to help clarify important principles and to present a picture of contemporary biology.

PROGRAM I

WHAT IS BIOLOGY?

This program is primarily a general introduction to the series. It states first that the series is about biology and then poses the question, "What is biology?". To answer the question there follows a series of interviews with Drs. Yarrington, Fisher, Rothfels, Stoskopf, Thomson, Till, Fry, Mr. Walden and Dr. Zimmerman whose respective fields are ecology, physiology, cytology, botany, genetics, immunology, ichthyology, wild life biology, and cell biology. Each briefly explains something about the work he does and some of the apparatus and specimens he uses.

In spite of the great diversity shown by these nine individuals the common factor is that the basic unifying feature is their work with living things. The question is then asked, "What are living things?" This question is answered pictorially by an immense diversity of living organisms. After this brief survey the final question is asked, "How do we recognize a living thing?" The program is concluded with a discussion of the characteristics of living things and the differences between the living and non-living. The characteristics of living things are broken down into five major characteristics, which, of course, is a rather arbitrary division that could be modified, condensed, or expanded to suit the observer.

PROGRAM 2

LOOKING AT CELLS

ELECTRON MICROSCOPY

This program deals with electron micros-

copy in two phases — first, the preparation of the specimen to be examined, and second, the interpretation of what is seen. After a brief introduction dealing with the physical principles of the light and electron microscope, Dr. Allen Bell at the Marine Research Station, Wood's Hole, Massachusetts is introduced. Dr. Bell describes the preparation of a specimen for electron microscope study. The specimen used is the eye of the common sea scallop. The discussion follows through fixation with osmium tetroxide, dehydration in increasing concentrations of alcohol, and embedding in an epoxy resin and the polymerization of this resin by heat. An explanation is made of staining techniques using heavy metals. The operation of a microtome is illustrated by Dr. Bell. He also demonstrates the method of judging the thickness of the sections: that of the reflection of light showing interference colours. This allows for sections to be cut 600 to 900 Angstrom units in thickness. The card showing the interference colours is marked in millimicrons. Finally Dr. Bell shows a typical electron microscope and describes its function.

The balance of the program is devoted to Dr. Keith Porter of Harvard University, one of the foremost authorities on the fine structure of cells. Dr. Porter starts with a brief discussion of a liver cell as seen by means of the light microscope. He then discusses a series of different cells as seen by means of the electron microscope. The electron micrographs are those of cells of the liver and pancreas (acinar cells), plasma cells, granulocytes (eosinophil), muscle cells, erythrocyte and erythroblast, and finally cells of the digestive epithelium. The mitochondria, endoplasmic reticulum, microsomes (specifically ribosomes) and the Golgi apparatus are discussed with regard to appearance, structure and possible function. Dr. Porter mentions, but does not discuss, the nucleus, nuclear envelope, pores in the nuclear envelope and lysosomes. He also discusses some special functions of cells or parts of cells — eosinophils, myofibrils of muscle cells, erythrocytes, erythroblasts, sodium pump, and finally the brush border

of the digestive epithelium with its microvilli. All the micrographs used have been produced by Dr. Porter.

PROGRAM

3

THE MEMBRANE OF THE CELL

STRUCTURAL DETAIL

In this program the membrane system of the cell is discussed, particularly the plasma membrane and the various proposed means by which materials pass through this membrane.

The program opens with an amoeba engulfing a food particle from which the discussion leads to the question, "Is the material within the cell or outside the cell?" The terms phagocytosis and pinocytosis are used. A molecular explanation is discussed by means of animation and electron micrographs. The principles of random movement, diffusion, concentration, polymerization, osmosis, osmotic pressure, equilibrium, and ions are used in this explanation, as well as the control by the cell itself. The last part of the program is devoted to two interviews, one with Dr. Jack Dainty of the University of East Anglia England and the other with Dr. W. Thompson of the University of Toronto.

Dr. Dainty deals with the movement of material across the cell membrane and the energy relationships involved. His analogy for active transport and the carrier system is that of a ferry boat. In his discussion he mentions various metabolites, the sodium pump, the carrier theory, proteins as the carrier and the specificity of carriers. Dr. Thompson in his interview discusses the Danielli-Davson model and the Robertson model of the plasma membrane. The phospholipid and protein layers are discussed as well as some of the experimental evidence to back up the bimolecular concept of the membrane. The terms "lipid phase" and "polar head groups" are mentioned. In this interview there is also presented the techniques of thin layer chromatography.

PROGRAM

4

RESPIRATION 1 – THE OVERALL PICTURE

Having considered the membrane and how materials pass through the membrane into the cell, we continue by discussing some of the vital processes that occur within the cell. Of these respiration is one of the most important. The cell as we have seen earlier, is a highly organized structure and this organization cannot be maintained without the continual expenditure of energy. It is the role of respiration to make this energy available in a form useful to the cell.

CHEMICAL PROCESSES INVOLVED

The program opens by considering the necessity that all living things have for energy. A discussion of the nature of chemical potential energy follows and analogies are drawn between it and other forms of potential energy. The idea of foods as sources of materials with relatively high chemical potential energy is introduced. The question of what form of energy is of most use to the cell is discussed. It is pointed out that the work of the cell is chemical work and therefore the kind of energy the cell requires is chemical potential energy. The object of respiration therefore is not to convert the chemical energy of foods into other forms of energy but to repackage it in smaller, more reactive and less wasteful parcels. Consideration is then given to the role of the phosphagens and ATP as the vehicles by which the chemical energy of foods is repackaged and transferred in the cell to materials that must be lifted higher on the potential energy scale before they can react and perform the cell's work. Throughout this discussion are the concepts of exergonic and endergonic reactions as well as activation energy.

CELLULAR BREAKDOWN OF GLUCOSE

The respiratory process is then placed within its overall content in the body and its dependence on circulation and gas

exchange made evident. Taking glucose as an example of a typical food, the various stages in its breakdown within the cell are explained. The discussion starts with the pyranose structure of glucose after which the steps of glycolyses are discussed. This discussion involves conversion glucose to glucosphosphate, fructose diphosphate to triose phosphate to finally pyruvic acid (or pyruvate). The anaerobic conversion of pyruvic acid to lactic acid and alcohol are covered. Krebs cycle is discussed in relative depth. Throughout the production, and/or use of ATP, ADP, hydrogen, NAD, oxygen, acetyl CoA, water, and carbon dioxide is referred to as well as the role of the respiratory chain.

The program concludes with a consideration of the overall efficiency of the process in terms of the percentage of chemical potential energy of the glucose molecule that is actually repackaged into ATP.

PROGRAM

5

RESPIRATION 2 – THE MITOCHONDRION AND THE RESPIRATORY CHAIN

In program four an overall picture of respiration was presented, its significance and the chemical events that accompany the repackaging of the chemical potential materials that undergo respiration. Only passing reference was made to the role of the respiratory chain.

Program five takes a closer look at the respiratory chain, its role in the uptake of oxygen, the production of ATP and the removal and transfer of hydrogen from the respiratory substrates. The approach is that of some of the experimentation which went to support the current theory. Most of this experimentation duplicates the work done by such individuals as Warburg and Thunberg.

OXYGEN INVOLVEMENT

The program opens with experiments which would indicate that carbon dioxide is produced and oxygen is consumed. The ultimate fate of the oxygen is shown by

an experiment using a living organism and heavy oxygen. The question is then asked, "Where in the organism is oxygen actually used?" To partly answer this the Warburg apparatus and its function are used. The preparation of the liver homogenate is followed right from the freshly killed rat, to finally the tissue homogenate in one series of experiments, to a mitochondrial separation in another series, and finally to a physical breakup of the mitochondria in the final series.

The first series demonstrates that respiration progresses only so long as sufficient glucose is present (sufficient oxygen is present throughout). The second series demonstrates that the mitochondria and glucose show no respiratory acceleration, but that the mitochondria and lactic or pyruvic acid show respiratory acceleration. The final series demonstrates that although the necessary enzymes are present within the mitochondria the intact structure of the mitochondria is necessary for maximum efficiency.

HYDROGEN REMOVAL

The latter part of the program deals with the question "Where is hydrogen removed?" To answer this the work of Thunberg, Warburg and Keilen is referred to. The concept of a hydrogen acceptor (Thunberg's theory of dehydrogenases) is illustrated using some of Thunberg's methods — methylene blue as a hydrogen acceptor and the Thunberg tube. The use of vital stain — Janus green — is demonstrated to show that it is within the mitochondria that dehydrogenation occurs. The work of Otto Warburg and George Keilin is then mentioned regarding the discovery of the iron porphyrins and other cytochromes and the yellow enzyme-FAD. The importance of the absorption spectrum as a laboratory tool is illustrated. The program then closes by showing the probable path and fate of the hydrogen and the electrons and finally the conversion of phosphagens to ATP. The importance of order to the sequence the enzymes along the membranes of the mitochondria is stressed.

PROGRAM

6

RESPIRATION 3 — ATP, THE CELL'S ENERGY CURRENCY

In the two preceding programs it was shown that a large part of the chemical potential energy of substrates undergoing respiration, is repackaged in the form of ATP. Program six considers in greater detail the nature of ATP and the precise ways in which it functions as an energy transfer substance.

After a general introduction in which the production ATP in respiration is briefly reviewed, the point is made that the ATP molecule has greater chemical potential energy than the ADP and inorganic phosphate from which it was made and that this extra energy must have come from the molecules undergoing respiration.

The concept of "bond energy" is then discussed and illustrated with reference to the build-up of ATP from its components. The terms "high" and "low" energy bonds are considered. The transfer of bond energy to ADP to form ATP in the course of respiration is then discussed and illustrated.

ATP USED IN THE CELL

Having considered the formation of ATP, the program continues with a discussion of how ATP is used or "spent" in the cell. The task of uniting a free glucose molecule to the end of a polysaccharide chain, as must occur in the synthesis of glycogen or starch, is introduced as typical of the chemical "work" the cell is called upon to perform. The role of ATP in transferring bond energy to the glucose is carefully explained as well as the reasons why this transfer must occur. Two demonstrations are then given of the actual use of ATP, — muscle contraction and firefly fluorescence. Dr. Mackelroy of the University of Toronto then discusses the role of ATP as a common carrier, or as an intermediate carrier of energy from one compound to another. Dr. Mackelroy then demonstrates the ability of the mitochon-

dria to convert ADP to ATP using the pyruvate as an energy source. The program ends with a summary of the relationship between respiration and the ATP-ADP level of the cell, and also the fate of the substrates if the cell has sufficient ATP.

PROGRAM

7

DNA THE SELF- DUPLICATING MOLECULE

STRUCTURE OF DNA

Program seven deals with the structure of DNA, particularly from the point of view of how we have found out what that structure is, and how this unique structure permits the DNA molecule to replicate itself.

The reproduction of individual cells, and hence of the entire organism since it is composed of cells, is based on cell division. But the external changes we see in dividing cells are really only the outward reflection of a molecular event that has already occurred in the cell. This is the replication of the nucleic acid, the DNA, in the nucleus of the cell. If the first living thing was some sort of DNA molecule and the cell and even the entire organism are the devices that have been evolved through natural selection to ensure the replication of DNA, then this process must be of fundamental importance.

Dr. Lou Siminovich of the University of Toronto, opens the program with a discussion of Avery, McLeod and McCartney's work with the pneumococcus bacteria. By means of simple diagrams and animation Dr. Siminovich summarizes their work of transferring DNA from one strain of pneumococcus to another strain and observing the resultant changes. He concludes this first section with a presentation of the structure of DNA — deoxyribose, phosphoric acid, and the nitrogenous base to form a nucleotide and the two main categories of nitrogenous bases — purines and pyrimidines and the four specific bases — adenine, guanine, cytosine and thymine. As an introduction to Dr. Fuller, Dr. Siminovich briefly discusses x-ray diffraction.

An interview with Dr. Watson Fuller of the University of London then follows. Dr. Fuller was a member of the team of crystallographers who gathered the data from which the Watson-Crick model of DNA was evolved. In his laboratory at King's College, Dr. Fuller shows how the X-ray diffraction work was done and outlines the process that must be gone through in order to derive the model. He concludes by describing the structure of DNA molecule as it finally emerged.

DNA REPLICATION

The program is concluded by Dr. Siminovich who discusses how a complete knowledge of the structure of DNA has enabled scientists to understand how it is possible for the molecule to replicate itself. This process is shown in animation.

PROGRAM 8

THE DIGESTIVE SYSTEM

Although all the processes necessary for the maintenance of life occur within the single cell, they can often be performed more efficiently by a multicellular organism. This is because cellular differentiation can occur, with certain groups of cells becoming specialized so as to carry on more efficiently a particular task. Because of the efficiency made possible by specialization and the division of labour, increasingly complex multicellular organisms evolved in both the plant and animal kingdom. But this complexity introduces problems of control and co-ordination that are not encountered by simple one-celled organisms. It is therefore necessary, after considering the life of the single cell and its molecular bases, to proceed to a study of the lives of the complex multicellular organisms.

ENZYME ACTION IN DIGESTION

In mammals, as in all animals, one of the never-ending preoccupations is with food. Program eight deals with digestion, the problem of releasing the nutrient materials from foodstuffs and absorbing these into

the body. Because enzyme action is so important to digestion, opportunity is taken to introduce some basic principles concerning enzymes and their action, using the digestive enzymes as examples.

After establishing the anatomy of the digestive tract by means of micrographs and dissection, the physical breakdown of foodstuffs is considered in its various steps. The micrographs illustrate quite clearly the four basic layers of the alimentary canal as well as various modifications of these layers. A dissection of the cat shows the various regions of the tract as well as the mesentery. By means of X-ray and actual observation, peristalsis and movement is clearly seen in various regions of the G.I.T.

The role of the teeth, salivary glands, tongue, taste pits and stomach is considered. It is then shown why physical breakdown is not, in itself, enough and that chemical breakdown must also occur so macro-molecules are broken into units small enough to diffuse through the semi-permeable membranes lining the intestine. The basic chemical structure of the three principal macromolecules in foodstuffs is then considered, — polysaccharides, proteins and lipids. The hydrolysis of each of them in the digestive tract is discussed.

The carbohydrate breakdown begins with starch to form a six unit sugar which is degraded to a disaccharide and finally to the monosaccharide glucose. Proteins are discussed in a similar fashion beginning with polypeptides and by means of the breaking of peptide bands to form polypeptides to peptones to dipeptides to finally amino acids. During this discussion mention is made of feedback, initiated by the stimulation of receptors in the duodenum to cause inhibition of gastric juice secretion but stimulation of pancreatic secretion.

With fats hydrolysis of the ester linkages are noted as is the emulsifying action of bile.

The last portion deals with the size of the absorbing surface, the structure of the villi and their function. The summation of the program stresses the importance of enzyme activity and its specificity.

PROGRAM 9

MUSCLES & MOVEMENT

Movement is a property that we associate instinctively with life. Program nine discusses muscle and its relationship to movement.

The program opens with a general discussion of bone and skeleton.

Using as an example, the biceps and triceps the program discusses movement on the basis of antagonistic pairs of muscles:

To answer the question "What is muscle?" the program uses light and electron micrographs.

Dr. Kamminer of the Muscle Research Institute at Wood's Hole is introduced. Dr. Kamminer demonstrates and discusses the action of ATP on a prepared piece of muscle fibre, bringing into the discussion the concept of actin and myosin and actomyosin.

The remainder of the program is an interview with Dr. H. E. Huxley of Cambridge University. Dr. Huxley is a leading expert in the field of the ultra structure of muscle and the mechanism of its contraction. By means of diagrams and electron micrographs he explains what is known about the ultrastructure regarding its contraction. Dr. Huxley mentions the A bands, I lines, H zones, I bands, ATP use and cross bridges.

He closes the interview with a presentation of how the impulse is transmitted to all parts of the muscle to cause contraction.

PROGRAM 10

NERVES AND NERVE IMPULSES

CO-ORDINATION AND CONTROL

In a multicellular animal that must move from place to place, the problem of co-ordination and control is of major importance. One method of accomplishing this

is by means of a nervous system. Program ten deals with the question of nervous control. It concentrates on the nature of the nerve itself and on the impulse that passes along it.

The program is presented as answers to the three questions —

- 1) What is the structure of a nerve?
- 2) What is the nature of the message?
- 3) How are the messages transmitted?

Micrographs and animation are used to answer the first question, showing the actual growth of a neuron and its association with other types of cells.

Animations and demonstrations are used to answer the second question regarding the nature of the message. The "all or none" law is discussed as are the terms depolarization, action and resting potential, refractory period, ion concentrations, acetylcholine, self propagation and synapse.

The interviews with Dr. Hoskin and Dr. Dettbarn of Marine Biology Research Station Wood's Hole, Massachusetts give answers to the latter two questions. Dr. Hoskin demonstrates the dissection of a giant axon of the squid and preparation and study of the propagation of nerve impulses along it.

Dr. Dettbarn discusses the movement of ions across the cell membrane and the possible role of acetylcholine.

The program terminates with a presentation of how a motor impulse would be transferred to a muscle fibre.

PROGRAM



INSULIN — A CO-ORDINATING CHEMICAL

The nervous system evolved in response to the need in the higher animals for a rapid co-ordinated response to sudden changes in the environment. An older and more basic form of control however exists side by side with the nervous system. This is a system of co-ordination involving

the use of chemical signalling substances called hormones that diffuse through the body and bring about a slower more prolonged response than that to the nervous system. Program fifteen attempts to establish some of the basic principles involved in this chemical control of the animal body.

HORMONE IMBALANCE

The program begins by showing some of the effects of hormones in humans. The hormone-producing areas of the body are designated and a description in general terms of the following glands is considered —

the pituitary, thyroid, parathyroid, adrenal, islets of the pancreas, ovary, testes and the secreting cells of the walls of the stomach and duodenum. Specifically mentioned are the hormones thyrotropic hormone, thyroxine, adrenocorticotrophic hormone (ACTH), corticoids, progesterone and testosterone. Relationships between the pituitary and the thyroid, pituitary and the adrenals, the adrenals and the kidneys, the adrenals and growth, and the adrenals and ovaries and testes are presented and discussed.

INSULIN

The program then goes into a more detailed consideration of one particular hormone, insulin. Its production in the Islet tissue of the pancreas and its effect on metabolism are described. An interview with the co-discoverer of insulin, Dr. Charles Best, of the University of Toronto, is then presented. Dr. Best outlines the way in which he and Sir Frederick Banting established the endocrine function of the pancreas, its effect on the individual cell and some of the major problems still to be solved in connection with insulin. In this discussion reference is made to the terms diabetes mellitus, glucagon and acidosis.

REGULATORY FUNCTIONS

The program concludes with a brief survey of some of the regulatory functions performed by chemical messengers in both plants and animals.

PROGRAM

12

HOW PLANTS LIFT WATER

Having considered some aspects of the life of a multicellular animal, we next turn to the life of the flowering plant. Equally complex in many respects, the higher plants have evolved a way of life that is based on completely different principles from those regulating animal physiology, even though there is an underlying unity in the problems that must be solved.

TRANSPIRATION

One of the most intriguing questions in plant physiology is the problem of water movement. How is the water absorbed, what forces are responsible for lifting it through the tremendous heights encountered in some trees, why is the water needed in such large amounts? Program twelve attempts to answer some of these questions. The first point established is that leaves are exposed to much more radiant energy than they can possibly use and that the evaporation of water from their interior surfaces may serve the useful purpose of dissipating some of this excess radiant energy. The role of the stomata in regulating the evaporation of transpiration of water is described. Reference is made to the amounts of water transpired by different kinds of plants.

WATER MOVEMENT THEORIES

The question is raised of where this water comes from. This leads into a consideration of soil and capillary water and the role of the root hairs in absorbing it by osmosis. By reference to the anatomy of vascular plants, the pathway of water through the plant is demonstrated.

Four of the different theories as to how the water moves through the xylem are then advanced and the evidence for and against them considered. The four theories presented are — air pressure, capillary action, root pressure and leaf pull.

Out of the consideration of these four theories, a description of the leaf pull or cohesion theory emerges as the most

acceptable. Experimental evidence supporting it is presented and also the weaknesses are also very clearly enunciated. The program ends with a brief reference to the plant growth system as it is related to water movement.

PROGRAM 13

BIOLOGY OF THE FLOWER

The reproduction of the flowering plant, like that of any other organism, is based on the division of cells. The types of cell division involved in plant reproduction, are centered in a special organ, the flower. Program thirteen describes the events upon which the sexual reproduction of the seedproducing plants is based, as they occur, on the cellular level, in the various parts of the flower.

The program begins by describing the primordia within the plant tissue from which the flower buds and later flowers will develop. The development is followed through from the mass of cells in the ovule to development of the embryo sac with the final dependant organism within the ovule. A similar presentation is used to show the development of the pollen grains.

Pollination is discussed under the general headings of wind and insect transfer and also controlled transfer as practised by man to produce e.g. hybrid corn. The further development of the pollen grain after transfer to the stigma is illustrated and the typical double fertilization of the angiosperm is described. The seed formation is then presented with some mention of the production and effect of auxins to finally produce a fruit.

The latter part of the program discusses photoperiodism — the long day and short day plants, auxin production and action, temperature as a modifying factor and other possible plant hormones e.g. gibberellin.

PROGRAM 14

SEXUAL REPRODUCTION

Having considered the reproduction of single cells by mitosis, and the reproduction of a typical complex multicellular organism, the next topic to be discussed is that of reproduction in general.

Program fourteen deals with the significance of sexual reproduction in promoting variation and describes the process of meiotic cell division and syngamy (fertilization) that must accompany it.

The program opens with examples of various gametes. It then goes on to discuss the structure of the megagamete (ovum) and microgamete (spermatozoan) involving the terms vitellus, nucleus, plasma membrane, zona pellucida, and acrosome, ring, centriole, and tail.

Dr. Leonard Nelson at Woods Hole Marine Research Station, Massachusetts discusses external fertilization. He demonstrates the use of electricity and chemicals to stimulate release of eggs and sperm by the sea urchin.

The necessity of internal fertilization for land dwelling animals is pointed out.

Drs. Arthur and Laura Colwin also at Woods Hole Marine Research Station present the results of their research on the mechanism of egg penetration by the sperm, based on electron microscopic studies of fertilization. Their discussion is followed by an animated sequence to illustrate this penetration.

The necessity of meiosis at some point in the reproductive cycle is then pointed out. In this discussion, reference is made to the following terms — monoploid, diploid, polyploid, cross over, synapses, tetrad, homologue chromatids as well as the main divisions of meiosis — prophase, metaphase, anaphase, telophase in stages I and II.

Meiosis is presented by means of anima-

tion with chromosomes from each parent coloured differently so that the student can see the "mixing" of maternal and paternal characteristics in the resulting gamete.

PROGRAM 15

THE TRANSMISSION OF GENES

MENDELIAN LAWS OF INHERITANCE

The function of reproduction is not merely to produce new individuals, but individuals having the same general characteristics as their parents. To understand the laws governing the transmission of these inherited characteristics from one generation to the next has been one of the major problems of biology. The object of program fifteen is to describe the first steps that were made towards an understanding of this problem. The topic is approached historically by showing how the Mendelian laws of inheritance can be derived from cross-breeding experiments and how these in turn lead to the chromosome theory of inheritance.

After a brief introduction to genetics in which the terms quantitative and qualitative are defined with regard to genetics, the work of Gregor Johannes Mendel is introduced. Dr. Kert Stern of the University of Southern California at Berkeley presents Mendel's work with pea plants. The method of pollination, the particular characteristics of pea plants, the type of crosses and the results are discussed. The predicted and actual results are shown for crosses involving one and two traits. Dr. Stern presents three major principles of Mendelian genetics;

1. segregation
2. independent assortment
3. dominant and recessive characters

The program finishes with Thomas Hunt Morgan's work with fruit flies and the concept of the gene. Finally the relationship between DNA and the chromosome is pointed out.

PROGRAM 16

THE EXPRESSION OF GENES

To understand something of how genes are transmitted from one generation to the next explains nothing of the nature of the gene or of how it manages to mould the growth of the organism in some particular direction. Program sixteen is concerned with these problems — the nature of the gene and how it expresses itself.

The program is built around the answers to the three following questions;

1. Are protein characteristics controlled by DNA?
2. How is the information of DNA transcribed to proteins?
3. How is the information of DNA transferred chemically so that the correct proteins are produced?

The metabolic disorder of humans — galactosemia is used to answer the first question.

The second question is discussed and answered by Dr. L. Siminovitch of the Department of Medical Biophysics, University of Toronto and the Princess Margaret Hospital. He uses some of the experimental work dealing with the bacteria *Escherichia coli* and a virus which infects this bacteria. Dr. Siminovitch then goes on to discuss the structure of DNA and protein. Using the protein myoglobin he shows the reasoning for the development of the three base code.

Dr. Paul Gross of the Massachusetts Institute of Technology a leading researcher in the field of protein synthesis, particularly in the early stages of embryonic development answers the third and final question. Each of the three types of RNA — ribosomal, messenger and soluble is discussed on the basis of composition, function and production. The three RNA's are then brought together to form a protein from the various amino acids. Dr. Gross also mentions aggregates of ribosomes which allow for the production of several proteins at the same time. To answer Dr. Gross' question "How is the information

in DNA used by the living cell to make proteins"? he modifies what Francis Crick once called the central dogma of molecular biology: DNA makes RNA which makes proteins.

PROGRAM 17

THE EVIDENCE FOR EVOLUTION

CHARLES DARWIN

Since the dawn of life, at the time of the creation of the first self-duplicating molecule, there has been a steady increase in the variety and complexity of living things. To explain how this diversity has come about has been one of the great challenges to biological science. It was Charles Darwin who first assembled complete and systematic proof of the fact of evolution, of the gradual change through time of one species of organism into another. It was he who realized that the steady tendency of populations to increase, held in check only by the unrelenting pressure of food limitation and the conditions imposed by the environment and predation, could provide the basis for the mechanism by which evolution operated.

Program seventeen presents the classical evidence for the fact of evolution. A large part of the program takes the form of an extended interview with Sir Gavin de Beer F. R. S. formerly Director of the British Museum (Natural History) and the author of many works on evolution. The program is concluded with an interview with Dr. Alfred Romer of Howard University.

Sir Gavin de Beer in his discussion, points out that Darwin was a master of observation and that only after gathering vast amounts of evidence, both for and against, and weighing them, did he finally publish his "Origin of Species." Sir Gavin mentions the ideas of isolation, adaptive radiation and niches particularly with regard to the Galapagos Islands.

The arguments in favour of evolution which Sir Gavin de Beer mentions are:

- 1) comparative anatomy
- 2) embryology
- 3) serology
- 4) paleontology

In each case he uses specific examples for illustration.

Dr. Romer in his discussion, covers the probable changes which happened tying them in with changes in environment.

PROGRAM 18

MECHANISM OF EVOLUTION

To establish the fact of evolution is one thing, to explain how it comes about is another. The great virtue of Darwin's work was that he not only established the fact of evolution, but suggested the theory of natural selection to account for its operation.

Program eighteen explains the theory of natural selection and shows how inherited variation, the raw material upon which selection acts, is produced.

Sir Gavin de Beer introduces the program with a very brief summary of Lamarck and Erasmus Darwin's theory of evolution. He soon goes on to Charles Darwin's seven points regarding the mechanism of evolution:

- 1) huge number of sperm and eggs
- 2) numbers of individuals remain constant
- 3) enormous mortality rate
- 4) no two individuals alike
- 5) variation
- 6) some variants survive better
- 7) heredity

The point is emphasized that the struggle for existence results in the survival of the fittest and that natural selection is the mechanism of evolution.

The program then considers that section of which Darwin had no knowledge — genetics. Two basic questions are asked:

- 1) how does variation occur
- 2) how does natural selection work on variation

The sources of variation are discussed under the headings of:

- 1) meiosis
- 2) fertilization
- 3) mutation

Under meiosis segregation, crossing over and altered gene combinations are discussed, with fertilization, and recombination. For mutation the disease sickle cell anemia is discussed both from its advantages and disadvantages to a particular population of humans.

The discussion up to this point is summed up by two equations:

mutations + sexual reproduction

= natural selection

natural selection + time

= evolution

The second question is discussed by Dr. Stoskopf of Guelph University. With the discussion centred on the corn plant, Dr. Stoskopf shows how variation is used by agriculture to produce selected varieties, and that natural selection is used. Dr. Stoskopf also points out that man can and does interfere with the survival of the the fittest, and can induce mutation.

social sciences have their distinct problems, but these are related one with the other. Man (*Homo sapiens*) is unique and it is this uniqueness which presents problems as well as benefits to man's existence.

Dr. Bates looks at and discusses four of what he feels are the major problems facing mankind:

1. population
2. war
3. resources
4. deterioration of environment

These four problems are discussed in the light of physical, biological and social approaches. His picture is not entirely that of an optimist, but he leaves it up to the viewer to think about solutions to these problems.

PROGRAM

19

MAN IN BIOLOGY

The final program in this series deals with man and his relationships with himself and with the world about him. Up to this program the series has presented and discussed well defined subjects which fall into clear cut categories. However, science is not a world unto itself but must relate not only with itself but with the world about it.

A large part of program nineteen is composed of an interview with Dr. Marston Bates of the University of Michigan, Ann Arbor. In this interview Dr. Bates points out that the physical, biological, and

SCIENCE — BIOLOGY — Senior Division
 19 programs, 30 minutes each

Prog. No.	CBC 9:30-10:00	CBLT 10:00-10:30	CHCH 9:30-10:00	CKCO 9:45-10:15	CJOH 9:10-9:40	CBOT 10:00-10:30	CKLW 10:00-10:30
1	JAN. 11 — 10:00-10:30					JAN. 11	JAN. 11
2	OCT. 2 JAN. 18 — 10:00-10:30	OCT. 18 — 9:40-10:10	OCT. 18	JAN. 10	OCT. 21	JAN. 8 JAN. 18	JAN. 17 — 10:15-10:45 JAN. 18
3	OCT. 29 NOV. 19 JAN. 25 — 10:00-10:30	NOV. 15 — 9:40-10:10	NOV. 8	JAN. 31	NOV. 4 — 9:30-10:00	JAN. 22 JAN. 25	JAN. 25 FEB. 7 — 10:15-10:45
4	NOV. 19 DEC. 10 FEB. 1 — 10:00-10:30	DEC. 6 — 9:40-10:10	NOV. 29	FEB. 17 — 9:30-10:00	NOV. 18	JAN. 29 FEB. 1	FEB. 1 FEB. 24
5	DEC. 10 JAN. 7 FEB. 8 — 10:00-10:30	DEC. 18	JAN. 20	MAR. 4	DEC. 17	FEB. 8	FEB. 8 MAR. 11 — 10:15-10:45
6	JAN. 7 FEB. 15 — 10:00-10:30		JAN. 21			FEB. 15	FEB. 15
7	JAN. 28 FEB. 22 — 10:00-10:30	JAN. 15	FEB. 10	APR. 8 — 9:30-10:00	JAN. 13 — 9:30-10:00	FEB. 22	APR. 15
8	FEB. 8 MAR. 1 — 10:00-10:30	FEB. 3	MAR. 3		FEB. 28 — 9:30-10:00	MAR. 1	MAR. 1 MAY 2 — 10:30-11:00

SCIENCE — BIOLOGY — Senior Division (continued)
 19 programs, 30 minutes each

Prog. No.	CBC 9:30-10:00	CBLT 10:00-10:30	CHCH 9:30-10:00	CKCO 9:45-10:15	CJOH 9:10-9:40	CBOT 10:00-10:30	CKLW 10:00-10:30
9	FEB. 25 MAR. 4 MAR. 8 — 10:00-10:30	FEB. 26 — 10:00-10:30	APR. 15	MAY 13 — 10:00-10:20	MAR. 24 — 9:30-10:00	MAR. 8	MAR. 8 — 10:00-10:30 MAY 20 — 10:30-11:00
10	MAR. 29 — 10:00-10:30					MAR. 29	MAR. 29 — 10:00-10:30
11	APR. 5 — 10:00-10:30					APR. 5 — 10:00-10:30	APR. 5 — 10:00-10:30
12	APR. 1 APR. 12 — 10:00-10:30	MAR. 26 — 10:00-10:30	MAY 6	MAY 27 — 10:00-10:30	APR. 14 — 9:30-10:00	APR. 12	APR. 12 — 10:00-10:30 JUNE 3 — 10:30-11:00
13	APR. 19 — 10:00-10:30					APR. 19	APR. 19 — 10:00-10:30
14	APR. 26 — 10:00-10:30					APR. 26	APR. 26 — 10:00-10:30
15	MAY 3 — 10:00-10:30 MAY 6	APR. 30 — 10:00-10:30	MAY 22		APR. 29 — 10:00-10:30	MAY 3	MAY 3 — 10:00-10:30
16	MAY 10 — 10:00-10:30					MAY 10	MAY 10 — 10:00-10:30
17	MAY 17 — 10:00-10:30 MAY 20	MAY 21 — 10:00-10:30	MAY 27		MAY 16 — 9:35-10:05	MAY 17	MAY 17 — 10:00-10:30
18	MAY 24 — 10:00-10:30					MAY 24	MAY 24 — 10:00-10:30
19	MAY 31 — 10:00-10:30					MAY 31	MAY 31 — 10:00-10:30

SCIENCE-BIOLOGY